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(54) Guest-Host Effect Liquid Crystal Display Device

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Specification

1. Title of the Invention

Guest-Host Effect Liquid Crystal Display Device

2. Scope of Claims

1. A guest-host effect liquid crystal display device in which an electric field is applied to a mixed thin layer in which a polygenetic dye is used as a solute and a liquid crystal material is used as a solvent, so that distortion of alignment of liquid crystal molecules is generated to cause an optical change, characterized in that no electrode is formed on one of substrates which form the display device and an electrode structure of the other substrate is an interdigital structure in which two electrodes are formed parallel to each other.

2. A guest-host effect liquid crystal display device in which an electric field is applied to a mixed thin layer in which a polygenetic dye is used as a solute and a liquid crystal material is used as a solvent, so that distortion of alignment of liquid crystal molecules is generated to cause an optical change, characterized in that at least one electrode is formed on one of substrates which form the display device and an electrode structure of the other substrate is an interdigital structure in which two electrodes are formed parallel to each other.

3. Detailed Description of the Invention

The present invention relates to an electrode structure of a display device to which a so-called guest-host effect in which a mixed system in which a polygenetic dye is used as a solute and a liquid crystal material is used as a solvent is formed into a thin layer with a thickness of about from 5 to 15 μm and an electric field is applied, so that distortion of alignment of liquid crystal molecules is generated, and accordingly, optical density of a specific light wavelength region is changed is applied.

As a guest material used for the guest-host effect, for example, a dye with a high dichroic property, such as Sudan Black B, Sudan Red BB, Sudan III, or 4-nitro-4′dimethylaminoazobenzene is used. As a host material, a nematic liquid crystal, a smectic liquid crystal, and a cholesteric liquid crystal are used. For example, MBBA (methoxybenzylidene-butylaniline) or the like is given for a nematic liquid crystal with negative dielectric anisotropy, and pentyl cyanobiphenyl or the like is given for a nematic liquid crystal with positive dielectric anisotropy. These liquid crystals to serve as hosts may be not only a single component but also a mixed liquid crystal in which several components are mixed. As the components, not only a nematic liquid crystal but also a cholesteric liquid crystal, a smectic liquid crystal, or a compound of an optically-active substance, a surface-active substance, and

the like, which are not liquid crystal materials, may be mixed.

In a liquid crystal element having a sandwich structure, as for a guest-host effect in the case where liquid crystals having negative dielectric anisotropy are hosts and polygenetic dyes are guests, when initial alignment of liquid crystal molecules is homeotropic alignment, the alignment of the liquid crystal molecules is turned into homogeneous alignment by application of an electric field. In addition, when polarization of incident light is set in a direction of dipole moment of the dye, color of a portion without electric field disappears whereas a portion to which a certain amount or more of electric field is applied is dyed. This method is suitable for so-called positive display because an effective active electrode portion (an electrode portion in which an electric field can be applied to a liquid crystal layer) of a transparent electrode is dyed. However, this method has defects in that a contrast ratio cannot be easily obtained and a response characteristic is not good, and thus this method is not suitable for practical use.

On the other hand, good results of a contrast ratio and a response characteristic can be obtained in the case where liquid crystals having positive dielectric anisotropy are used as hosts and polygenetic dyes are used as guests. However, since color of the effective active electrode portion disappears and other portion without electric field is dyed, so-called negative type display is obtained in which color of a portion to which an electric field is applied disappears and other portion is dyed in the case where a positive type effective active electrode pattern is used in a sandwich structure. This problem is a cause of dark display for reflective display in which a display element is irradiated with surrounding light.

The present invention is made in view of the problem. It is an object of the present invention to provide a device which is capable of positive display by a guest-host effect in which liquid crystals having positive dielectric anisotropy are used.

In a guest-host effect liquid crystal display device of the present invention, an electrode structure for applying an electric field is that no electrode is formed on one of substrates and an interdigital structure in which two electrodes are formed on the same plane of the other substrate is employed. Alternatively, an electrode structure has a sandwich structure and electrodes on one of substrates have an interdigital structure.

One implementation of the present invention is hereinafter explained with reference to drawings.

FIG. 1 is a structural diagram of a display device of one embodiment of the present invention. Two electrodes 4 and 4' are formed parallel to each other on the same plane of an electrode-side substrate 3 which is opposed to a substrate 1. Although the electrodes 4 and 4'

may have a character pattern or a figure such as a circle, they definitely need to be formed parallel to each other. Therefore, the same character patterns are formed parallel to each other when the character pattern is employed, and concentric circles are formed when the figure of a circle is employed.

Then, a driving power source 5 is connected between the electrodes 4 and 4'. Then, a portion between the substrates is filled with liquid crystal molecules 2 and polygenetic dyes 6. Accordingly, a liquid crystal display device is formed.

In this case, a mixed system of the liquid crystal molecules 2 and the polygenetic dyes 6 has homeotropic alignment (vertical alignment) as an initial alignment state.

In this operational mechanism, a mixed system of liquid crystals having positive dielectric anisotropy and dyes has homeotropic alignment as initial alignment, and when power supply voltage from the driving power source 5 is applied between the two electrodes 4 and 4' on the electrode-side substrate 3 which is one of the substrates, the liquid crystal molecules 2 are realigned, by this electric field, in the direction of the electric field. Therefore, the polygenetic dyes 6 are also realigned in the same direction and a change in absorbance is generated. Accordingly, display can be performed. FIG. 4 is a spectrum diagram of absorbance on the assumption that an incident light ray of ON is parallel to long axis directions of the liquid crystal molecules 2 and the polygenetic dyes 6.

FIG. 2 is a diagram for explaining a state of the display device when power supply voltage from the driving power source 5 is not applied. FIG. 3 shows a diagram for explaining a state thereof when power supply voltage from the power source 5 is applied.

Although in one embodiment of the present invention shown in FIG. 1, the mixed system of the liquid crystal molecules 2 having positive dielectric anisotropy and the polygenetic dyes 6 has homeotropic alignment as initial alignment by treatment of a substrate surface, the mixed system can have homeotropic alignment as initial alignment also by an electric field.

FIG. 5 is a structural diagram of a display device of another embodiment of the present invention. Substrates 3 and 3' are placed parallel to each other, and an electrode 4 is formed on one substrate 3 and two electrodes 4' are formed parallel to each other on the other substrate 3'. Then, a driving power source 5 having a potential of V_1 is connected between the electrodes 4 and 4', and a driving power source 5' having a potential of V_2 is connected between the electrodes 4' which are parallel to each other. Then, a portion between the substrates is filled with liquid crystal molecules 2 and polygenetic dyes 6. Accordingly, the display device is

formed.

The operation of this display device is explained. First, when the driving power source 5' is turned off and power supply voltage from the driving power source 5 is applied, a mixed system of the liquid crystals has homeotropic alignment as shown in FIG. 6.

Next, when power supply voltage from the driving power source 5' is applied, the mixed system is realigned in a direction of an electric field. Accordingly, display can be performed. Note that power supply voltage from the driving power source 5 is not applied at this time. This display device does not particularly need treatment of a substrate surface, and a color-disappearing state and a dyed state are both active states; thus, the display device has a feature in that turn-on time and turn-off time can be controlled by driving voltage and a very fast response characteristic can be obtained.

As described above, in the present invention, an electrode structure for applying an electric field is that no electrode is formed on one of substrates and an interdigital structure in which two electrodes which are parallel to each other are formed on the same plane of the other substrate is employed.

Alternatively, electrodes have a sandwich structure and electrodes on one of substrates have an interdigital structure.

When the display device of the present invention is used, a contrast characteristic and a response characteristic are excellent and positive display can be performed, and reflective liquid crystal display which can be driven with low power consumption can be obtained.

4. Brief Description of the Drawings

FIG. 1 is a structural diagram of a liquid crystal display device of one embodiment of the present invention.

FIG. 2 and FIG. 3 each are a diagram for explaining the operation of the display device.

FIG. 4 is a spectrum diagram of the display device.

FIG. 5 is a structural diagram of a liquid crystal display device of another embodiment of the present invention.

FIG. 6 and FIG. 7 each are a diagram for explaining the operation of the display device.

1: substrate, 2: liquid crystal molecule, 3 and 3': electrode-side substrate, 4 and 4': electrode, 5 and 5': driving power source, and 6: polygenetic dye.

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(54) GUEST HOST EFFECT TYPE LIQUID CRYSTAL DISPLAY DEVICE

(57)Abstract:
PURPOSE: To perform positive displaying with the guest host effect using liquid crystal having positive inductivity by forming the electrodes on one of base plates in interdigital structure.

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⑭ゲストホスト効果型液晶表示装置

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㉒出　　願　昭51(1976)10月14日
㉗発 明 者　船田文明
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明　細　書

1. 発明の名称

ゲストホスト効果型液晶表示装置

2. 特許請求の範囲

1. 多色性染料を溶質とし、液晶材料を溶媒とした混合系薄層に電界を印加し、液晶分子配向変形を生じさせて光学変化を起こすゲストホスト効果型液晶表示装置において、前記表示装置を構成する一方の基板には電極を形成せず、他方の基板の電極構造が二電極をその電極間隔を平行に構成したインターディジタル構造としてなることを特徴とするゲストホスト効果型液晶表示装置。

2. 多色性染料を溶質とし、液晶材料を溶媒とし ［illegible］ タル構造としてなることを特徴とするゲストホスト効果型液晶表示装置。

3. 発明の詳細な説明

本発明は、多色性染料を溶質とし、液晶材料を溶媒とした混合系を、約5μmから20μm程度の薄層にし、電界を印加させることにより、液晶分子配向変形を生じさせ、その結果として、特定光波長域の光学濃度を変化させるいわゆるゲストホスト効果を応用した表示装置の電極構造に関したものである。

ゲストホスト効果に用いるゲスト材料としては例えばスーダンブラックB、スーダンレッドBR、スーダンⅢやｐ・ニトロ・ジメチルアミノアゾベンゼン等の二色性の強い染料が用いられる —

シアノバイフェニール等がある。これらのホストとする液晶は、単一成分のみならず数種の成分を混合した混合液晶でもよく、その成分としてネマティック液晶のみならず、コレステリック液晶、スメクティック液晶や液晶物質ではない光学活性物質や界面活性物質等の化合物が混合されていてもよい。

ところで、サンドイッチ構造を有した液晶素子において、負の誘電異方性を有した液晶をホストとし、多色性染料をゲストとした場合のゲストホスト効果では、初期液晶分子配向をホメオトロピック配向にしておくと、電界印加により液晶分子配向がホモジニアス配向化する。又入射光の偏光を染料のダイポールモーメント方向にしておくと無電界の場所は消色を呈し、一定以上の電界が印加された場所は着色する効果を示す。この方式は透明電極の有効活性電極部分（液晶層に電界が印加されうる電極部分）が着色するのでいわゆるポジ表示をするのに適している。しかしながらこの方式の欠点として、コントラスト比が得難いことや応答特性が良好でないことがあり、実用には適していない。

一方正の誘電異方性を有した液晶をホストとし多色性染料をゲストとした場合には、コントラスト比や応答特性は良好な結果が得られるが、有効活性電極部分が消色し他の無電界部分が着色するため、サンドイッチ構造でポジティブタイプの有効活性電極パターンを用いた場合には、電界が印加された場所が消色し、他の場所が着色するといういわゆるネガティブタイプの表示となる。この問題は、表示素子を周囲光で照射して用いる反射型表示にとっては、表示の暗さを招く原因となっている。

本発明は、この点を解決するためになされたものであり、正の誘電性を有した液晶を用いたゲストホスト効果でポジティブ表示をすることが出来る装置を提供することを目的とする。

本発明の構成はゲストホスト効果型液晶表示装置において電界を印加するための電極構成が一方の基板には電極を形成せず他方の基板の同一平面内に二電極を有するインターディジタル構造とするものである。あるいはサンドイッチ構造を有する電極構成であり、その一方の基板上の電極がインターディジタル構造をなすものである。

以下図面に従い本発明一実施例を説明する。第1図は本発明一実施例の表示装置構成図である。基板2に対向する電極側基板3の同一平面上に二つの電極4，4′がその電極間隔を平行にして構成されている。電極4，4′の形状としては文字パターンや円形の図形であってもよいが必ずその電極間隔を平行にする必要がある。このため文字パターンにおいては同一の文字パターンを平行にして形成し、円においては同心円として構成することになる。

この動作機構は、正の誘電異方性を有した液晶・染料混合系を初期配向としてホメオトロピック配向化させておき、一方の電極側基板3上に有する二つの電極4，4′間に駆動用電源8を印加すると、この電界により液晶分子7は電界方向に再配向する。このため多色性染料6も同じ方向に再配向し、吸光度に変化を生じるのであり、表示が出来ることとなる。第4図は吸光度のスペクトル図であり、オンの入射光偏光は液晶分子7、多色性染料6の長軸方向に平行としてのスペクトル図である。

第2図は駆動用電源8が印加されていないときの表示装置の状態説明図であり、第3図は電源8が印加されたときの状態説明図である。

第5図は本発明他の実施例の表示装置構成図である。電極側基板3，3′を平行にして一方の基板3に電極4を構成し、他方の基板3′に対電極4′を二つ平行に構成する。そして電極4と対4′との間には電圧V_1の駆動用電源5を接続し、平行な電極4′の相互間には電圧V_2の駆動用電源5′を接続する。そして液晶分子2と多色性染料6との混合系を封入して表示装置を構成する。

この表示装置の動作を説明するとまず駆動用電源5′をオフにしておいて、同電源5を印加すると第6図に示すように液晶の混合系はホメオトロピック配向となる。

そして今度は電源5′を印加すると混合系は電界方向に再配向して表示が出来ることとなる。尚このときは電源5は印加しないでおく。この表示装置では、基板表面処理は特に必要でなく、着色状態も無色状態もともに安定な状態であるためターンオン時間及びターンオフ時間も駆動電圧で制御でき、非常に高速の応答特性を得ることができる特徴を有している。

以上のように本発明は電界を印加するための電極構成が一方の基板には電極を形成せず他方の基板の同一平面内に二つの平行電極を形成するインターディジタル構造とするものである。

あるいは前述のサンドイッチ構造を有するものであり、その一方の基板上の電極がインターディジタル構造をなすものである。

本発明の表示装置を用いれば、コントラスト特性や視角特性もよくポジティブ表示を行なうことが出来て、低消費電力で駆動が可能な反射型液晶表示が得られる。

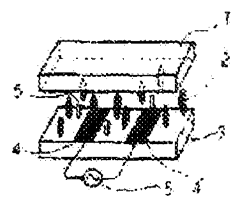
4. 図面の簡単な説明

第1図は本発明一実施例である液晶表示装置の構成図、第2図及び第3図は同表示装置の動作説明図、第4図は同表示装置のスペクトル図、第5図は本発明他の実施例である液晶表示装置の構成図、第6図及び第7図は同表示装置の動作説明図である。

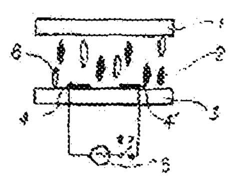
1・・・基板、2・・・液晶分子、3，3′・・・電極側基板、4，4′・・・電極、5，5′・・・駆動用電源、6・・・多色性染料。

代理人　弁理士　福士愛彦

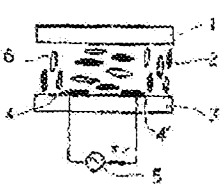
第1図



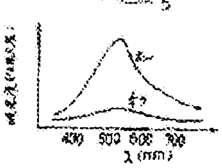
第2図

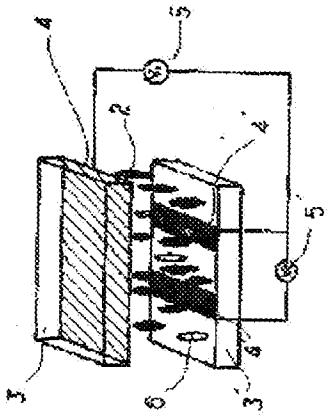


第3図

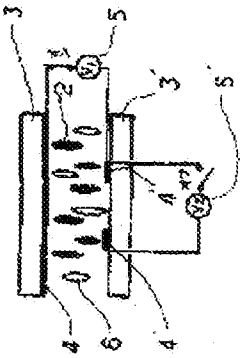


第4図

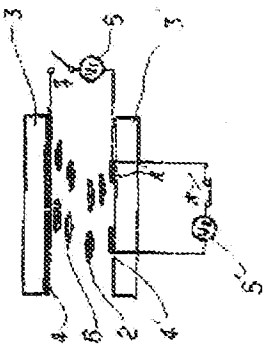




第5図



第6図



第7図